Instruction Manual

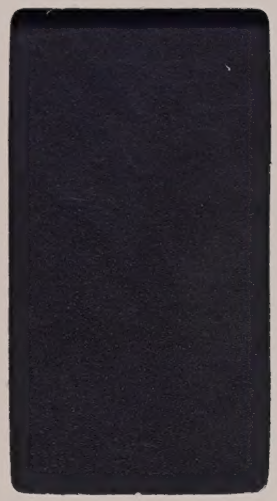
JOHN FLUKE MFG. CO., INC.

ELECTRONICS FOR INDUSTRY

Model 800

Differential DC Voltmeter

INSTRUMENTS / COMPONENTS



John Fluke Manufacturing Co., Inc.
P. O. Box 7428, Seattle 33, Washington

Model 800

Differential DC Voltmeter

Serial No. 1380 &on

MODEL 800 DC DIFFERENTIAL VOLTMETER

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MODEL 800 DIFFERENTIAL DC VOLTMETER

MODEL 800 DIFFERENTIAL DC VOLTMETER

CONVENTIONAL VTVM SPECIFICATIONS

Voltage Ranges:	0 to ±500, *0 to ±10, *0 to ±1 volts DC.
Input Resistance:	10 megohms.
Scales:	500-0-500, 1-0-1 volts DC.
Accuracy:	±4% of full scale.

*These ranges obtained by setting RANGE knob to either 10V or 1V with 5 voltage knobs set to 0.

DIFFERENTIAL VTVM SPECIFICATIONS

Voltage Range:	0 to 500 volts DC.
Input Resistance:	Infinite at null. 2000 megohms per volt of input voltage for 0.005 volt of unbalance as indicated by meter.
Scales:	1-0-1 and 10-0-10 volts DC.
Accuracy:	±0.05% of actual voltage from 10 volts to 500 volts. ±0.1% of actual voltage or 5MV, whichever is greater, below 10 volts.
Resolution:	0.01 volt read directly on calibrated controls. Greater resolution available by reading meter.
Stability of Reference Supply:	0.01% for 20% change in line voltage (105V to 130V). 0.01% per hour after warmup (adjustable by front panel CAL ADJ control).
Stability of Meter Zero:	5% of full scale for 20% change in line voltage (105V to 130V). 2% per hour after warmup (adjustable by front panel MTR ZERO control).
Calibration:	500 volt reference supply calibrated against built in standard cell.
Input Power:	100-130 volts, 60 cycles, 52 watts.
Dimensions:	Cabinet Model: 9-3/4" W x 13" H x 14"D. Rack Mounting Model: 19" W x 8-3/4" H x 16-3/4" D.
Finish & Weight:	Smooth grey panel. Grey baked leather grain case. Cabinet Model 21 lbs.; Rack Mounting Model 23 lbs.
Price:	$385 Cabinet Model; $405 Rack Mounting Model.

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASH.

MODEL 800
DIFFERENTIAL VOLTMETER

INSPECTION

This instrument has been thoroughly checked and tested before being shipped from the factory. Upon receipt of the instrument, inspect carefully for any damage which may have been incurred in transit. Reference should be made to the Warranty Section of this instruction manual for the procedure to be followed if any shipping damage has occurred.

INITIAL OPERATION

1. Connect the instrument to 117 volt, 60 cycle single phase source. Then turn on the instrument by turning the RANGE switch to the CAL position. Allow instrument to warm up for approximately five minutes.

2. After the warm up period, the instrument should be calibrated. Calibration of the instrument is accomplished with the RANGE switch in the CAL position, by turning the OP CAL switch to the CAL position with the left hand while adjusting the ADJ CAL control with the right hand for absolutely no deflection of the meter needle. Maximum accuracy is obtained with the Model 800 when this operation is carefully performed. Check for perfect null by turning and releasing the OP CAL switch and checking for no movement of the meter needle. When this operation is carefully performed the reference supply will be set to 500 volts within 0.01%.

3. Adjust MTR. ZERO knob. To do this, set RANGE switch to 500 position and bring meter needle to zero by adjustment of the MTR. ZERO knob (with nothing connected to the input posts.) Turn RANGE switch to 10V and 1V positions - meter should remain on zero.

4. During the first 20 minutes of operation it is advisable to check the calibration and meter zero once or twice, since maximum stability of both the 500 volt reference supply and the cathode follower VTVM is attained after the instrument has reached normal operating temperature.

TO MEASURE DC VOLTAGES

1. Determine the approximate value of the unknown voltage. Turn the RANGE switch to the 500V position and zero the meter by adjusting the MTR. ZERO control. Connect unknown voltage to be measured to the plus and minus terminals. With the RANGE switch in the 500 V position, the Model 800 functions as a conventional zero center, vacuum tube voltmeter with ten megohms input resistance and a 500-0-500 volt range. The voltage under measurement may be read to an accuracy of 4% in this position. A left hand deflection of the needle indicates that the leads to the instrument should be interchanged before attempting to make differential voltage measurements.

2. To measure DC voltages to 0.05%, set up the voltage indicated by the meter on the X100 and X10 controls. Then set the RANGE switch to the 10V position at which time the meter indicates the difference between the unknown voltage and the internal calibrated voltage. Next adjust the voltage knobs until the meter reads less than 1 volt of unbalance. Now turn the RANGE switch to the 1V position for greater sensitivity and again adjust the controls, particularly the X0.1 and X0.01 controls, until the meter reads zero. The unknown voltage may now be read directly on the five voltage dials accurate to 0.05% of the actual voltage (0.1% or 5MV below 10 volts.)

OBSERVING EXCURSIONS OF A VOLTAGE ABOUT A NOMINAL VALUE

Set up the nominal voltage on the five voltage dials as outlined above and observe the excursions directly on the meter in either the 10V or 1V position of the RANGE switch. A right hand deflection of the needle indicates that the voltage under observation has increased above the nominal value by the amount indicated by the meter reading; a left hand deflection indicates the voltage has decreased by the amount indicated by the meter reading.

RECORDER OUTPUT PROVISIONS

The Model 800 includes provisions for recorder monitoring or for recording the excursions of the unknown voltage from the voltage indicated by the dial settings.

WARNING

NOTE ONE: The leakage resistance between the recorder used and ground must be greater than 500,000 megohms or the accuracy of the 800 will be impaired. Therefore, the John Fluke Manufacturing Company recommends that the John Fluke A-70 Potentiometric Recorder (manufactured by the Texas Instrument Company) be used with the Model 800. In all cases, teflon leads should be used to connect the Model 800 to the recorder.

NOTE TWO: Do not ground either of the recorder output terminals to the chassis of the Model 800, if a grounding link is being used on the front panel of the instrument. The 1/200 Ampere fuse which is in series with the Model 800 Kelvin-Varley divider will be blown if such a short circuit occurs. This fuse is located at the rear of the front panel and on the lower left side. The instrument must be removed from its case if replacement of this fuse is required.

1. Connect Recorder. The output terminals at the rear of the Model 800 must be isolated from ground when connected to the recorder. Connect the recorder and make one or both of the following checks:

A. Check One

(1) Connect a standard cell to the input of the 800.

(2) Measure the standard cell potential.

(3) Alternately connect and disconnect the recorder leads at the rear of the 800. If there is more than one-quarter of a small division deflection of the meter needle, leakage has been introduced by the recorder and the accuracy of the 800 will be impaired.

B. Check Two

(1) Zero the VTVM circuit.

(2) Set the RANGE switch to 500 volts, turn all five voltage dials to zero.

(3) Turn the voltage dials to register 400 volts. A properly operating 800 should show less than one-quarter of a small division deflection from zero as indicated on the meter. If there is more deflection, disconnect the recorder and repeat the operation to determine whether there is leakage in the VTVM circuit or whether leakage has been introduced by the recorder.

2. Operation. A signal of 15 millivolts maximum from the null detector is available at the recorder output posts at the rear of the Model 800. This signal may be varied by means of the GAIN ADJ potentiometer immediately adjacent to these posts. Accordingly, the recorder deflection may be adjusted to suit the particular application involved.

For example: if it were desired that full-scale meter deflection would result in full-scale recorder deflection, the instrument could be set up as follows:

A. Zero the meter on the Model 800.

B. Place RANGE switch in 10 Volt range.

C. Turn Kelvin-Varley dials to register 0.1 Volt.

D. Short out the 800 input.

E. Adjust ADJ GAIN control for full-scale recorder deflection.

TO USE AS A CONVENTIONAL VTVM ON THE TWO NULL RANGES

In addition to the 500-0-500 volt VTVM "Search" range in the Model 800, two additional ranges are available. These are 10-0-10 and 1-0-1 volts at 10 megohms input resistance. The ranges are available by setting all five voltage knobs to zero, connecting the voltage to be measured to the input posts, and setting the RANGE dial to the desired voltage range. Accuracy in these two additional ranges is ±4%.

MEASUREMENT OF HIGH VALUE RESISTANCES

The Model 800 may be used to measure resistances between 1 megohm and 500,000 megohms very quickly and conveniently. The unknown resistance can often be measured at any voltage between 0.01 and 500 volts to simulate actual operating conditions. Examination of Model 800 circuitry and

application of elementary circuit theory will produce the following equation for determining values of resistances with the Model 800:

$$RX = 10^7 \left(\frac{E}{Em} - 1\right)$$ where:

RX is the unknown resistance in ohms.
E is the voltage setting of the five voltage knobs.
EM is the meter reading on the appropriate scale; either 10-0-10 or 1-0-1 volt, as determined by the RANGE switch.
10^7 is the input resistance of the VTVM in ohms.

1. To measure high value resistance set the RANGE switch to either the 10V or 1V position. Zero the meter by means of the MTR. ZERO control.

2. Connect the unknown resistance between the plus and minus terminals. Buss the minus terminal to the ground terminal. Avoid the use of long twisted leads since the Model 800 can easily measure the leakage resistance of the insulation of such leads. It is best to use very short isolated leads. Connect the negative terminal to the grounded side of the resistance under measurement (if one side happens to be grounded) or to the common ground point if in a "floated" circuit.

3. Now adjust voltage controls to any desired value between 0.01 and 500 volts or to any voltage which allows convenient reading of the meter; that is, produces a reasonably easily read meter deflection of, for example, 10% of full scale.

4. Read the meter, the voltage dials and the RANGE switch and substitute these values in the above equation and compute the value of the unknown resistance.

5. For rapid measurement of resistances up to approximately 5000 megohms without use of the formula, merely set RANGE switch to the 10 volt position, adjust voltage dials for a full scale meter deflection and subtract 10 from the reading of the voltage dials. This is the value of the unknown resistance in megohms.

6. For rapid measurement of resistances up to approximately 5000 megohms without use of the formula, set RANGE switch to the 1 volt position and adjust voltage dials for full scale meter deflection. Subtract 1 from the reading of the voltage dials and multiply the difference by 10. This is the value of the unknown resistance in megohms.

CIRCUIT DESCRIPTION

The Model 800 Precision Differential DC Voltmeter operates on the potentiometer principle wherein an unknown voltage is measured by bucking it against an adjustable known voltage and reading the difference on a sensitive null detector. When zero displacement current flows in the null detector, the unknown voltage is exactly equal to the known voltage and impedance presented to the unknown voltage source by the known voltage source and null detector is infinite.

The circuit consists of five main elements, which are:

1. A super regulated, extremely stable 500 volt reference source.

2. Means for setting this reference source to 500 volts within ±0.01%.

3. A calibrated 5 decade Kelvin-Varley precision attenuator for dividing the reference voltage down to the exact level of the unknown voltage.

4. A calibrated multi-range VTVM which is used both as a conventional VTVM for determining the approximate value of the unknown voltage and as a calibrated null detector for measuring the difference between the unknown voltage and the known voltage derived from the 5 decade calibrated attenuator.

5. Appropriate attenuators for reducing the signal input to 1 volt maximum for the VTVM range and the first null range (10V).

Element 1 consists of an unregulated 900 volt DC supply (V1, R1, C10, C11, and C12), a pre-regulator delivering 625 volts at 1% regulation (V2, V3, V5 and associated components), and a superregulator delivering 500 volts at 0.01% regulation (V4, V6, V7, V8 and associated components). The super-regulator uses the highly stable type 5651 reference tubes, a carefully balanced differential amplifier as the equating element, and precision wirewound resistors in the sampling circuit. The stability of this 500 volt supply is better than 0.01% per hour after a short warm-up period.

Element 2 consists of P1, S7, a standard cell, a precision wirewound divider (R15, R19, R16, and P2) across the 500 volt supply from which is derived a voltage exactly equal to the EMF of the particular standard cell used when the output is exactly 500.00 volts, a 50-0-50 microamp meter M1, and RANGE switch sections S6C and E for connecting the meter between the standard cell and 1 volt sample of the 500 volt output.

To calibrate, S7 "OP-CAL" switch is turned to CAL position and P1 ADJ CAL knob is rotated until there is no deflection of the meter needle.

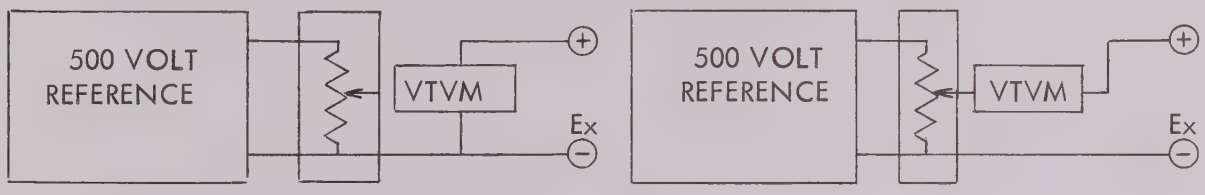
Element 3 is made up of S1, S2, S3, S4, S5, and associated matched precision wirewound resistors, R20 through R68. The resistors on the A switch are factory matched to be within ±0.005% of each other; those on the B switch to within ±0.012%; those on the C, D, and E switches to within ±0.025%. If any of the resistors in this 5 dial attenuator become defective, send resistor value and serial number of the instrument to John Fluke Mfg. Co., Inc., where a record is kept of the exact values used in each instrument shipped; in this way a replacement can be obtained which will not upset the matching of the other resistors on the particular switch.

Element 4 consists of a cathode follower type VTVM, V102 and associated components R103, R104, R105, C102, P101 (meter zero control for 500 V, 10V, and 1 V ranges), M1, and RANGE switch sections S6C and S6E for switching the meter from the CALIBRATE function to the VTVM function. This VTVM has a basic full scale sensitivity of 1 volt; that is, a 1 volt DC signal applied between pin 2 of V102 and the 0 volt bus of the voltmeter channel, with everything to the right of R105 cast loose, will cause the meter to deflect full scale right or left depending on whether the signal is positive or negative respectively (pin 2 with respect to 0 volt bus).

Element 5 consists of the appropriate sections of the RANGE switch S6, together with associated resistors R106 through R110. RANGE switch section S6D and resistors R108 through R110 divide the unknown voltage down to 1 volt from either 500 or 10 volts, depending on the setting of the switch. RANGE switch section S6A and resistors R106 and R107 are used to maintain the resistance between input grid of VTVM (pin 2 of V102) and negative side of voltmeter channel constant at 11 megohms.

In order to use the instrument as a straight VTVM, the negative input binding post is connected directly to the negative side of the voltmeter channel via RANGE switch S6F; the positive input binding post is connected to the RANGE switch divider via switch S6D and the VTVM input grid is connected to the output of the RANGE switch divider via switch S6A. This is illustrated in block diagram below.

In order to use the instrument in the differential mode, the entire voltmeter channel is "floated" between the output of the 5 dial attenuator and the positive input binding post. The block diagram below illustrates this.



5 Dial
Attenuator
STRAIGHT VTVM

5 Dial
Attenuator
DIFFERENTIAL VTVM

This is effected via RANGE switch section S6F while RANGE switch section S6D serves to attenuate the 10 volt out of balance signal (when operating in the 10 volt null range) to 1 volt for application directly to the cathode follower VTVM input grid (pin 2, V102). In the last position of the RANGE switch (1V) the out of balance signal is applied directly to the cathode follower input grid.

Screwdriver adjust control P102 is adjusted so that full scale meter deflection results when exactly 500 volts is applied to the input binding posts with RANGE switch set to 500V position.

This concludes the circuit description. Should trouble occur, an orderly step by step servicing procedure should locate the source. Refer to the "Trouble Shooting Hints" section of this book for assistance in isolating and repairing the fault. If trouble cannot be isolated, write us giving full details of the difficulty and include serial number. On receipt of this information we will send service data or shipping instructions.

CAUTION: IT IS RECOMMENDED THAT THE PLUG TO THE STANDARD CELL BE REMOVED WHEN TROUBLE SHOOTING TO PREVENT ACCIDENTAL SHORTING AND DAMAGING OF THE CELL.

MAINTENANCE NOTES

1. Tube replacement. All tubes used in the Model 800 are, with the possible exception of the type 5651 reference tubes, common receiving types. Only two of the 10 tubes used are at all critical - these are V6 in the 500 volt reference supply and V102 in the VTVM channel. Should replacement of these be necessary, the following procedure should be followed to insure optimum performance of the instrument. We recommend replacement of these two with factory pretested tubes.

   V6 - this tube is a high mu dual triode, type 12AX7, used as a differential amplifier. This connection insures maximum stability and minimum effects from line voltage change. Some tubes have poor balance between halves, however, causing poor regulation against line voltage. Check for this by allowing 5 minutes for tube to heat and then varying line voltage from 100 to 130 volts and checking reference supply output voltage with another 800 or 801. The 500 volts must not change by more than 50 millivolts (0.01%) over this range of line voltage. If regulation exceeds this figure discard tube in favor of another.

   V102 - this tube is a medium mu dual triode used in a cathode follower type VTVM circuit. The two requirements of V102 for satisfactory performance are good balance between halves and low grid current. These can be checked by setting RANGE switch to 1V position, and all 5 voltage knobs to zero. Allow a few minutes for tube heating and then check for ability to zero meter. At zero, the meter zero knob pointer should lie within ±90 degrees of vertical. If outside these limits, remove tube and try another. If okay, vary line voltage from 100 to 130V and check stability of meter zero. Meter should not offset more than 5% (2 small scale divisions). If it does, discard V102 in favor of another with better balance.

   To check for excessive grid current in V102, set RANGE knob to 1 volt position, the five voltage knobs to zero and line voltage to 117 volts. Zero meter and then short the input binding posts. Meter offset must not exceed 1/4 of one small scale division - if it does, replace V102. Shorting the input posts changes the resistance in the grid circuit of the right half of V102 from 10 megohms to 1 megohm. Assuming the small grid current to be constant (which is not strictly true) this change in grid resistance appears as a change in grid voltage which causes a small meter offset to the left. The average Amperex 12AU7 produces offset of from 1/4 to 1/2 of one small scale division. It is important that this offset be kept to a minimum in order that slight errors not result from measuring EMF's with widely varying internal resistances. This is not error due to external circuit loading since the 800 at null presents infinite resistance to the external circuit. Rather it is error due to shunting of the normal 10 megohms VTVM grid circuit resistance by the internal resistance of the voltage source under measurement.

   The John Fluke Mfg. Co., Inc., sales representative in your area maintains a stock of aged replacement tubes selected for optimum performance in these two critical spots (V6 and V102). If replacement becomes necessary, contact him and advise tube type required. This is usually simpler than selecting tubes from stocks on hand.

2. General Cleaning. The Model 800 is extremely sensitive to the slightest amount of electrical leakage from the VTVM channel, particularly the input grid of V102 (pin 2) and all its associated wiring to the negative side of the input. Leakage resistance of 40,000 megohms between this grid circuit and the negative input will cause a 10% left meter deflection in the 1 volt null range when voltage dials are set to 400 volts; lower values of leakage resistance will cause larger no signal meter deflection. An analysis of the 800 circuitry will show that it meters its own internal leakage resistance. Therefore, the instrument should be cleaned occasionally to remove dust and foreign matter. Blow the instrument out with a low pressure air hose (be sure air is dry) and wipe VTVM board and its mounting strips with a clean, dry rag. If necessary wipe the mounting strips with a rag saturated in Metriclene Solvent M-4 (manufactured by the John B. Moore Corp., Nutley, New Jersey). This is a high grade, non-toxic solvent for use on delicate electrical equipment. Many other solvents have very poor electrical properties and leave a residue which may be slightly conductive. Switches may be washed using a small stiff bristled brush dipped in Metriclene. After washing, the ceramic surfaces must be recoated with a 10% solution of Dow Corning 200 Fluid (100 viscosity grade) in Metriclene. This prevents moisture from collecting across the ceramic surfaces.

If the instrument is stored for a considerable period of time in a hot, humid atmosphere, considerable leakage may be noted upon initial operation. This is evidenced by large meter offsets in the null ranges as the voltage dial settings are increased. This usually clears up as the instrument warms up and dries out. If not, remove from case and wipe above mentioned surfaces with a clean dry cloth.

If necessary to clean binding post insulators, do not use Metriclene. Use only pure, denatured alcohol and a clean cloth since the insulator material is slightly solvent in Metriclene.

TROUBLE SHOOTING HINTS

1. Excessive drift in 500 volt reference supply - this is evidenced by having to recalibrate the unit every five or ten minutes for an hour or more. Trouble is usually a defective reference tube V7 or V8, or a faulty equating tube V6. A leaky feedback capacitor C6 may cause either drift or unstable operation.

2. Excessive drift in VTVM - drift should stop after a few minutes operation. If it persists, replace V102.

3. Inability to calibrate instrument - if meter deflection cannot be reduced to zero by following step 2 under "Initial Operation" trouble is one of the following:

   A. Either R17 or R18 has shifted, making it impossible to bring output of super-regulator to 500 V. Replace out of tolerance unit.

   B. V7 and/or V8 have aged to the point where their running voltage is too low. Replace them if this is the case. Their running voltage should lie between 85 and 87 volts. Screwdriver adjust control P3 may be adjusted to bring the front panel CAL ADJ control to the approximate center of its rotation at the point meter deflection has been reduced to zero.

Under no conditions attempt resistor replacement with ordinary power resistors, Nichrome resistors, carbon or deposited carbon resistors, or metal film resistors. This statement applies to every precision wirewound resistor in the instrument.

C. One of the three wirewound resistors in the standard cell sampling string has changed value. These are R15, R16, and R19. If replacement of any of these is necessary, the instrument must be recalibrated. See recalibration instructions.

D. The standard cell may have shifted value very badly. It should measure between 1.0190V and 1.0196V. Use only a Model 801 or a Leeds & Northrup Type K potentiometer (or other similar pot) to make this measurement. DO NOT USE A VOLTOHMMETER. If replacement of the cell is necessary, instrument must be recalibrated. See recalibration instructions.

E. Failure of either the rectifier filter (V1, C10, C11, C12), the super-regulated power supply (V4, V6, V7, V8) or the pre-regulator (V2, V3, V5). Output of the rectifier filter should run approximately 900 volts at a line voltage of 117 volts. Output of the pre-regulator should run 610 or 640 volts and be regulated to better than 1% over range of 100 to 130 volts line. Output of the super-regulator must obviously be 500 volts and should have a range of adjustability of at least 5 volts either side of 500. Regulation must be 0.01% or better over range of 100 to 130 volts line.

4. Error in excess of specified values. This is caused either by the instrument being out of calibration or by a defective resistor in the 5 dial Kelvin-Varley divider.

A. A quick check to determine whether this divider is okay consists of setting the 5 voltage dials to 400.00 and applying an EMF from an extremely stabile high resolution DC power supply, such as the John Fluke Models 301C, 406, or 407. Adjust supply until a null is obtained in the 1 volt range. Then remove voltage from input and reset the 5 voltage dials to 399.910. Reconnect the 400 volts to the instrument again with RANGE switch in 1V position. Meter should null within 80 millivolts (0.02%). Repeat this check applying 50 volts and setting up 50.00 first on the voltage dials and then 49.910. Difference in the two readings must be less than ±25 millivolts (0.05%).

Non-linearity is usually traceable to one defective wirewound resistor on one of the five switches. Since these are matched units, the drops across each resistor on a particular switch should lie within 0.01% of each other on X100, 0.025% on X10, and 0.05% on the other three. If replacement of any resistor is necessary, wire serial number of instrument to factory where a stock of matched replacements is maintained.

B. To determine whether instrument is still in calibration, perform the calibration operation as outlined in step 2 under "Initial Operation". Then apply a

KNOWN 500 volts - this voltage must be accurate to 0.01% or better - to the instrument and measure it. It must read between 499.90 and 500.10 volts (±0.02). If outside these limits follow recalibration instructions.

NOTE: A 500 volt EMF accurate to 0.01% is extremely difficult to obtain. If there is any doubt in your mind as to the accuracy of your 500 volts do not use it. Instead contact our field representative in your area. Most of them have in their repair stations a John Fluke approved precision calibration set up and therefore can perform this important check to the accuracy required.

5. Error in the VTVM readings - if meter reads off in the 500V search range as well as the 10 and 1 volt NULL ranges, adjustment of P102 is probably required. This is the screwdriver adjust potentiometer on the small printed circuit board. If error lies in only the 10 or 500 volt range, trouble is probably in divider string consisting of R108, R109, and R110.

   NOTE: DO NOT POKE AROUND THIS DIVIDER WITH A SHARP POINTED TOOL. IF A DEPOSITED CARBON RESISTOR COATING IS SCRATCHED DEEPLY ENOUGH THE RESISTOR WILL OPEN UP.

6. Meter needle offsets to the left as voltage dial settings are increased (RANGE dial in 1V position, nothing connected to the input posts) - this indicates leakages between grid pin 2 of V102 and the minus side of instrument. See MAINTENANCE NOTES under "General Cleaning" for discussion of this.

7. Excessive error which appears only at low voltages - this is caused either by a defective wirewound resistor on S4 or S5 (X.1 or X.01) or by excessive grid current of V102. See MAINTENANCE NOTES, page 7, for discussion of grid current. See TROUBLESHOOTING HINTS, heading 4A, for discussion of Kelvin-Varley non-linearity.

8. Meter needle rattle - trouble may lie in the source under measurement which is not steady or in the bucking voltage developed in the 800, or in the VTVM in the 800. To check the first two possibilities apply an absolutely steady voltage and see if meter needle wobble ceases. If it does, trouble was in the source. If wobble is still present, remove signal from input posts altogether. If wobble still is present, trouble is in VTVM. If wobble disappears, trouble is either in 500 volt reference supply or Kelvin-Varley divider.

   To track down trouble in 500V reference, use another Model 800 or 801 and monitor the output of the 500 volt reference supply of the defective 800. If 500 volts is steady, trouble is in Kelvin-Varley. If 500 volts is not stable, trouble may lie in R17, R18, R7 or any of the tubes in this supply. Also may be a leaky feedback capacitor C6. May also be caused by trouble in the 625 volt pre-regulator.

RECALIBRATION INSTRUCTIONS

If it has been positively determined that the instrument is out of calibration (see heading 4B), proceed as follows:

Apply a known 500 volts (accurate to 0.01% or better) to the instrument. Set 5 voltage dials to 499.910 and turn RANGE dial to 1 volt position. Bring needle to zero by adjustment of the ADJ CAL control. Then withdraw instrument part way out of the case to gain access to P2, a screwdriver adjust control located at the bottom of the large printed circuit board. Now turn RANGE knob to CAL position and rotate the CAL switch. Rock it back and forth and check for meter deflection. With a screwdriver, adjust P2 until the meter deflection has been eliminated when the CAL switch is rocked. The instrument is now back in calibration. Push instrument back in case and recheck calibration once more. If okay, apply a dab of Duco Household Cement to P2.

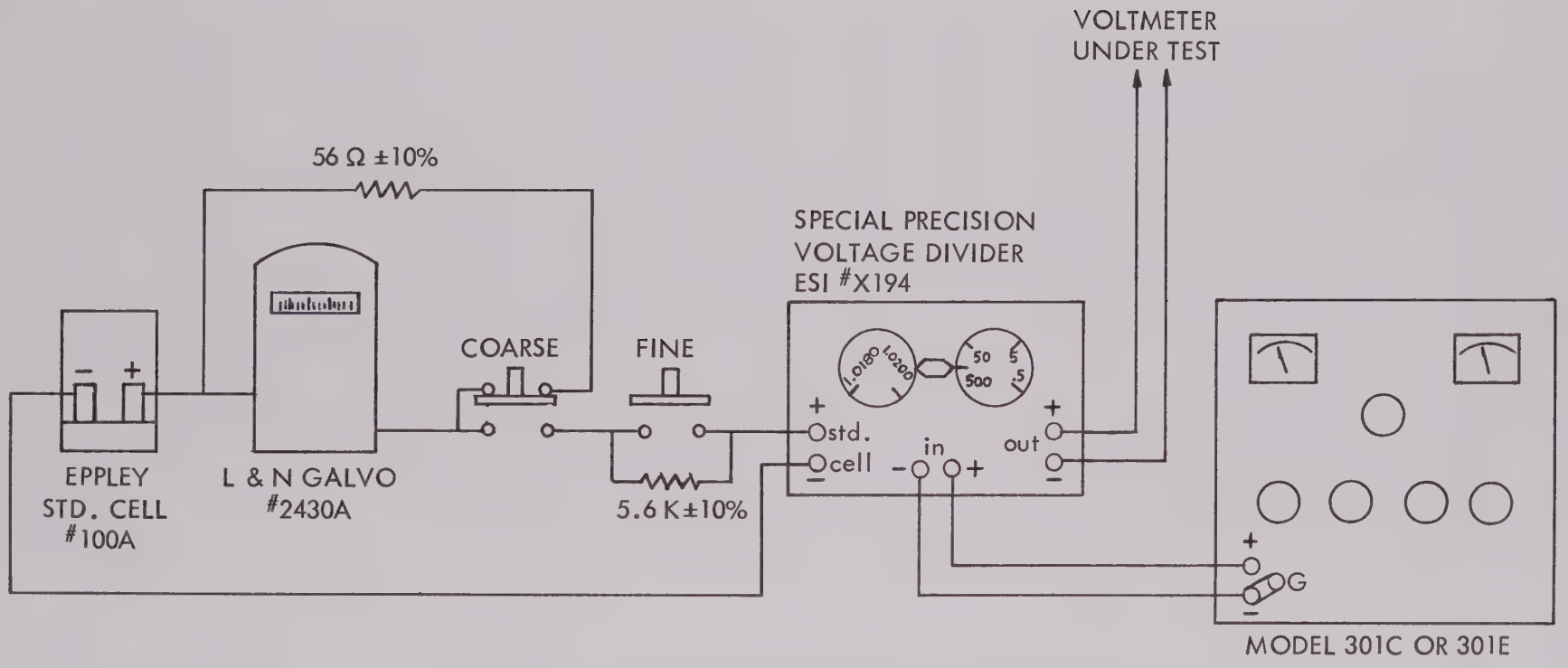
RECOMMENDED CALIBRATION SET-UP

The hook up of equipment required for final calibration of Models 800 and 801 is shown in Figure 1. The heart of this set up is the precision voltage divider, ESI #194, built by Electro Measurements, Inc., in Portland, Oregon. This divider is so constructed that when the left hand knob is set to the exact EMF of the Eppley standard cell shown at the extreme left and the 301C output voltage controls are adjusted until the Leeds and Northrup galvo comes to null with both COARSE and FINE buttons pushed, the EMF applied to the precision divider will be 500 volts within plus or minus 0.005%. The precision of this divider is such that the three divided down EMF's of 50 , 5 , and 0.5 volts will also be accurate to within plus or minus 0.005%. These figures obtain at 72 degrees F and the accuracy will be maintained within plus or minus 0.01% providing room temperature does not diviate more than plus or minus 5 degrees from this figure.

It is necessary, of course, that the EMF of the particular standard cell being used be known to an accuracy of plus or minus 0.002%. This means certification by some group who has a bank of saturated standard cells. The Eppley Model 100 standard cell is encased in a special phenolic housing which is thermally insulated and lagged. We strongly recommend that it be further insulated and lagged by housing it in an aluminum box inside of a wooden box with 3 inches of glass wool between cell and aluminum box and another 3 inches between boxes. While the Eppley 100 cell is of the unsaturated type which the Bureau of Standards will certify only to 0.01%, it will nevertheless maintain an extremely constant EMF if treated with care and not subjected to sudden temperature changes. Many groups will read an unsaturated cell's EMF down to the fifth place so that if you use this value in setting the standard cell knob of the ESI divider and treat the cell with care you can be reasonably sure that you are within plus or minus 0.002% (20 parts per million) of the true EMF of the cell. Overall accuracy of the system then is plus or minus 0.005% plus or minus 0.002% or somewhere between 0.003% and 0.007%, which is quite adequate for calibrating a 0.05% instrument.

TEST EQUIPMENT SET-UP FOR

FINAL CALIBRATION OF MODEL 800 SERIES VOLTMETER



COARSE & FINE SWITCHES ARE MOMENTARY PUSH BUTTON TYPE SHOWN IN NORMAL UNDEPRESSED POSITION. SINCE THESE SWITCHES ARE IN THE STANDARD CELL CIRCUIT THEY MUST HAVE FINE SILVER CONTACTS.

MODEL 800
LIST OF REPLACEABLE PARTS

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
C3	Capacitor, paper 0.1 mfd, 600 v	CP5
C5	Capacitor, paper 0.047 mfd, 400 v	CP6
C6	Capacitor, paper 0.01 mfd, 1600 v	CP1
C7,9	Capacitor, mylar 0.1 mfd, 600 v	CP20
C8	Capacitor, electrolytic 200 mfd, 6 v	CE30
C10,11,12	Capacitor, electrolytic 20 mfd, 450 v	CE65
C13	Capacitor, paper 0.1 mfd, 400 v	CP4
C101	Capacitor, electrolytic 8 mfd, 250 v	CE10
C102	Capacitor, paper 0.022 mfd, 600 v	CP18
R1	Resistor, composition 390 ohms, 10%, 1 w	GB3911
R2	Resistor, composition 470 k, 10%, 1/2 w	EB4741
R3A-F, R4A,B	Resistor, composition 22 k, 10%, 2 w	HB2231
R5	Resistor, deposited carbon 500 k, 1%, 2 w	DR620
R6	Resistor, deposited carbon 144 k, 1%, 1 w	DR67
R7	Resistor, precision wirewound 149 k, 0.5%, 1 w	PR611

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R8,12,14,105	Resistor, composition 1 m, 10%, 1/2w	EB1051
R9,10	Resistor, deposited carbon 300 k, 1%, 1 w	DR614
R13	Resistor, deposited carbon 250 k, 1%, 1 w	DR613
R15, 19	Resistor, precision wirewound 125 k, 0.1%, 1 w	PR610
R16	Resistor, precision wirewound 509 Ω, 0.1%, 1/2 w	PR37
R17	Resistor, precision wirewound 320 k, 0.5%, 1 w	PR614
R18	Resistor, precision wirewound 158 k, 0.5%, 1 w	PR620
*R20 - 25	Resistor, precision wirewound 40 k, 0.02%, 1/2 w matched	PR512
*R26 - 36	Resistor, precision wirewound 8 k, 0.05%, 1/2 w matched	PR48
*R37 - 47	Resistor, precision wirewound 1.6 k, 0.1%, 1/2 w matched	PR46
*R48 - 58	Resistor, precision wirewound 320 Ω, 0.1%, 1/2 w matched	PR39
*R59 - 68	Resistor, precision wirewound 64 Ω, 0.1%, 1/2 w matched	PR24
R69	Resistor, composition 39 k, 10%, 1 w	GB3931
R70,71,72	Resistor, composition 220 k, 10%, 1 w	GB2241
R101	Resistor, composition 100 Ω, 10%, 1 w	GB1011
R102	Resistor, composition 2.7 k, 10%, 1w	GB2721

*Factory matched. Specify instrument serial number for each resistor when ordering. See page 10, paragraph 5, of manual for additional information.

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
R103, 104, 111	Resistor, deposited carbon 8.2 k, 1%, 1/2 w	DR411
R106, 109	Resistor, deposited carbon 980 k, 1%, 1/2 w	DR623
R107, 108	Resistor, deposited carbon 9 m, 1%, 1 w	DR78
R110	Resistor, deposited carbon 20 k, 1%, 1/2 w	DR53
R112	Resistor, wirewound 10 Ω, 5%, 5 w	R10WA
P1	Potentiometer, wirewound 2 k, 10%, 2 w	P2KB
P2	Potentiometer, wirewound 5 Ω, 20%, 2 w	P5C
P3	Potentiometer, wirewound (Trimit) 10 k, 10%, 1/4 w, printed circuit type	P10KTA
P4	Potentiometer, wirewound 300 Ω, 20%, 2 w	P300A
P101, 102	Potentiometer, wirewound 5 k, 10%, 2 w	P5KA
V1	Tube, high vacuum rectifier Type 5AR4	5AR4
V2	Tube, pentode, type 6AQ5A	6AQ5A
V3	Tube, pentode , type 6AU6	6AU6
V4, 102	Tube, dual triode, type 12AU7	12AU7
V5	Tube, voltage regulator, type OA2	OA2
V6	Tube, dual triode, type 12AX7	12AX7
V7, 8	Tube, voltage reference, type OG3	OG3
V9	Tube, current regulator, type 9-7	9-7

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
V101	Tube, voltage regulator Type OB2	OB2
X101	Rectifier, selenium 117 v, 65 ma	RE1A
S1	Switch, rotary 2 pole, 5 position, shorting	SR40
S2,3,4	Switch, rotary 2 pole, 10 position, shorting	SR41
S5	Switch, rotary 1 pole, 11 position, shorting	SR42
S6	Switch, rotary 6 pole, 5 position	SR17A
S7	Switch, rotary Momentary on	SR16
B1	Standard cell, unsaturated Low hysteresis	X223
F1	Fuse, cartridge 2 amperes	F2
F2	Fuse, cartridge 1/200 ampere	F1/200
M1	Meter, 50-0-50 microamp with special scale	M12C
T1	Transformer, power	801-601
	Fuse holder, bayonet type	X12
	Binding post	X219
	Binding post insulator, black	X218
	Binding post insulator, red	X217
	Binding post spacer	X220

CIRCUIT SYMBOL	DESCRIPTION	FLUKE STOCK NO.
	Knob, 1-1/2 inch, no pointer	X234
	Knob, 1-1/2 inch, pointer	X207
	Knob, 1 inch, pointer	X231
	Cable, power, 3 conductor, #18	X27D
	Bushing, line cord strain relief	X138
	Feet, rubber mounting	X224
	Handle, leather	X373
	Washer, flat insulated for potentiometer mounting	X93
	Washer, shoulder insulated for potentiometer mounting	X93A

WARRANTY

The JOHN FLUKE MFG. CO., INC. warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken.

1. Notify the John Fluke Mfg. Co., Inc., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

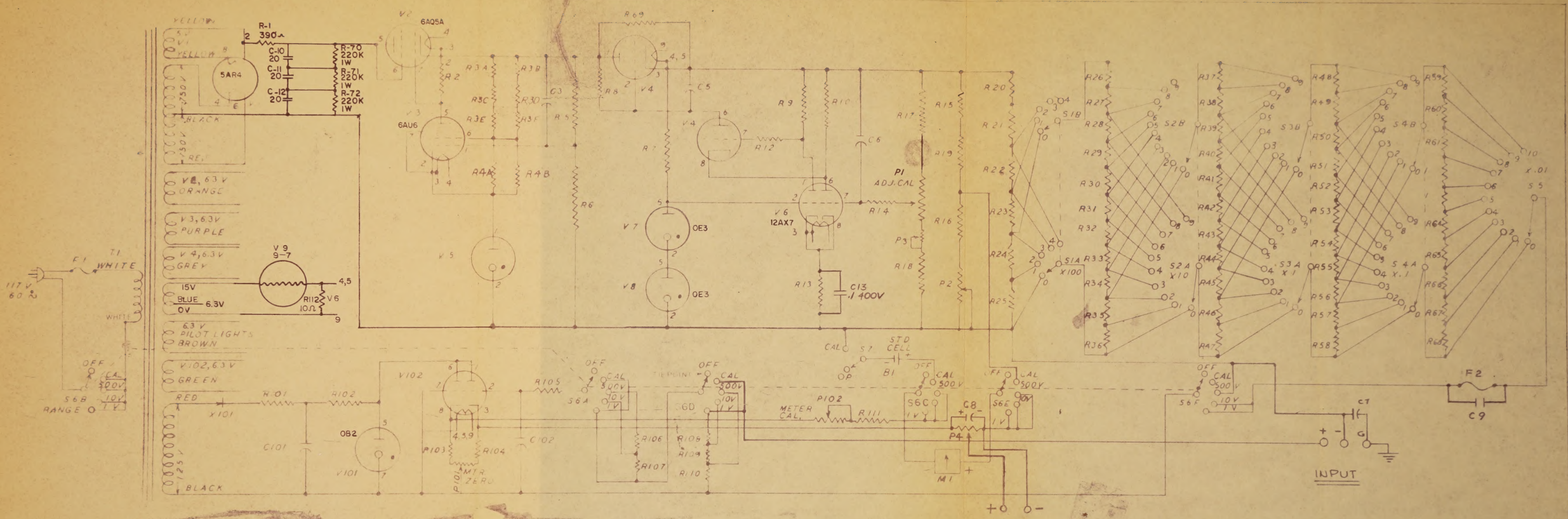
All shipments of John Fluke Mfg. Co., Inc. instruments should be made via Railway Express prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to John Fluke Mfg. Co., Inc. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

The John Fluke Mfg. Co., Inc. will be happy to answer all application questions which will enhance your use of this instrument. Please address your requests to:

JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON



SER 1380 & ABOVE

CIRCUIT DIAGRAM OF DIFFERENTIAL VOLTMETER

MODEL 800	DWG. 800-13
DATE 12-17-54	DRAWN BY VLH
CHECKED BY	

JOHN FLUKE MFG. CO. INC.
SEATTLE, WASH

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